METHODS FOR MAKING DISPERSANT USE DECISIONS

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ABSTRACT: *A decision for or against dispersant use involves several components, including considerations of operational feasibility and regulatory policy as well as environmental concerns. Eleven examples of the major published procedures for making oil spill response decisions, including decisions for or against use of chemical dispersants, are summarized and compared in this paper. These procedures are often depicted by decision diagrams, which are also included in the paper.*

If an oil spill occurs, several response options are possible. These options include mechanical recovery, use of dispersants, allowing for natural removal of oil from the environment, and cleanup of the shoreline or other area which may be impacted by the spill. The intelligent use of each of these options, where appropriate, will minimize (or reduce) environmental damage. It may be appropriate to use more than one option, simultaneously, in different parts of the spill.

A major problem is that of choosing which countermeasure(s) to use for each spill situation. One purpose of this paper is to aid in making these choices by providing descriptions of several approaches which are currently available. Another purpose is to emphasize the role of dispersants in oil spill mitigation and to show how decisions regarding dispersant use are made. These decision making methods have been published elsewhere; they are summarized here to provide a convenient single reference.

The spill response decision making methods which have been published can be divided into three categories:

1. **General purpose.** These decision making methods include consideration of the three major means of oil spill response: mechanical cleanup, dispersant use, and natural removal. Six general purpose decision making methods are described in this paper (Methods 1 through 6, below). Although these methods have strong similarities, each emphasizes a different aspect of oil spill response.
2. **Dispersant use agreements.** These letters of agreement between states or territories (such as Puerto Rico or the U.S. Virgin Islands) and the U.S. Government identify conditions or areas within which the federal on-scene coordinator (OSC—usually the U.S. Coast Guard) may make dispersant use decisions without further concurrence from other agencies. Two letters of agreement are discussed in this paper: Hawaii and Florida (Methods 7 and 8).
3. **Dispersant use recommendations.** These are procedures which are intended to aid in determining whether dispersant use would result in more or less environmental damage than if the spill were not treated. Three of these procedures are discussed here (Methods 9–11).

Procedures for making oil spill response decisions are often illustrated by decision diagrams such as those shown in Figures 1 through 5. Most of these diagrams are qualitative and do not give detailed guidance on the bases for making decisions, whether regarding mechanical containment and removal, or the use of dispersants. An exception is the Environmental Protection Agency (EPA) computerized spill response decision tree,[6] described in Method 1. This decision tree provides information at each node of the diagram (tree) to help the user.

Most of the published decision diagrams show dispersant use as an alternative to mechanical containment and recovery, assuming that mechanical means are not effective. In almost all cases, the question is posed, "Will environmental impacts associated with chemical dispersion be less than those occurring without chemical dispersion?" But, with the exception of the three methods described below, no guidance is offered to the on-scene coordinator to answer this question.

Dispersant use recommendations

The use of an oil spill dispersant is usually appropriate if the environmental damage caused by the dispersed oil is judged to be less than that which would be caused by untreated oil. Three methods are currently available to aid in making this judgment.

S. L. Ross Environmental Research, Ltd. (SLR) has developed a system for computing the impacts of untreated oil and dispersed oil on the populations at risk in an oil spill, and for comparing their overall effects (Method 9). SLR calls theirs a workbook method for making dispersant use decisions. However, recently it has been programmed for use on appropriate microcomputers, which greatly speeds up use of the method in complex environmental systems (such as the U.S. Gulf of Mexico).

Research Planning Institute (RPI), under contract to the American Petroleum Institute, has developed a system for displaying on a chart those areas in which dispersant use would be (a) highly recommended as a means of protecting nearby sensitive habitats, (b) acceptable if spill control is warranted but the oil is not likely to impact sensitive resources, and (c) conditional, depending on local protection priorities and the tradeoffs which should be considered owing to the effects of dispersed oil on, for example, benthic organisms (Method 10).

The American Society for Testing and Materials (ASTM) has developed consensus guidelines for the use of dispersants to clean up or to protect thirteen different habitats (Method 11).

Summary

Methods 1–11 summarize some of the most important guidelines available today for making oil spill response decisions. Most of these guidelines emphasize dispersant use decisions; in some cases, the guidelines contain diagrams to depict the logic used in making decisions.

The oil spill response methods outlined in Methods 1–8 all note that dispersant use should be authorized only when such use will reduce the overall environmental impact of the spilled oil. However, none of these eight methods offer guidance to the OSC in making the needed environmental evaluation. Methods 9, 10, and 11 are the only ones currently available to aid in making this judgment. These three methods concentrate on the ecological considerations of oil spill response and the possible effects of dispersant use and do not consider other aspects of spill mitigation.

Methods for making spill response decisions

Method 1. EPA computerized spill response decision tree.[6] The decisions which may be taken at the time of an oil spill are outlined in the decision tree shown in Figure 1. This decision tree has been programmed for use on a personal computer. It shows the types of decisions which usually must be made in the event of an oil spill at sea and it suggests the types of responses which are likely to be appropriate, with particular emphasis on dispersant use. By means of help menus in the program, many of the factors which are likely to enter into decision making at each step in the process are outlined or explained.

This decision tree does not provide guidance to the user for comparing the environmental impacts of dispersant use with those of untreated oil. Instead, the program recommends dispersant application rates which are conservative and unlikely to cause any discernible environmental damage. The program also identifies habitats in which dispersant use is usually preferred, a viable option, not advisable, or should be avoided altogether.

This decision tree is the basis for the dispersant use plan which has been adopted by Federal Region II.[10]

Help menus in the EPA decision tree. Help menus are provided in the computer program to assist the user; for this paper, the help menus (below) have been paraphrased and are shown as footnotes (a–q) keyed to particular sections of the decision tree shown in Figure 1.

a. Aerial surveillance is usually one of the best ways to determine the nature and extent of a spill, but the observer should be trained in aerial surveillance of oil spills.
b. A spill may not be visible because of such considerations as poor viewing conditions, or the possibility that the oil may have sunk.
c. Possible safety hazards include explosion, fire, and the presence of hydrogen sulfide, among other things.
d. Actions may include allowing the vapors to dissipate, avoiding ignition sources, and covering with foam.
e. The trajectory of a spill on the water surface can be estimated by vector addition of the current speed and three percent of the wind velocity. Maps should be available which indicate environmentally sensitive areas.
f. Thickness may be estimated from the spill volume divided by the area covered. If the oil layer is thin, oil thickness can sometimes be estimated from the presence of interference tints and rainbows. Note that oil usually is not uniformly distributed on the water surface.
g. Most oil spill recovery equipment in use today is incapable of recovering spilled oil effectively in seas more active than sea state 3. However, some can operate effectively up to sea state 4.
h. Oil on water will normally be dispersed mechanically into the sea if the sea state is greater than 5.
i. If the (average) oil thickness is greater than 0.5 mm, mechanical recovery can be practical and effective. However, a decision to use mechanical recovery should not preclude the use of dispersants in another part of the same spill.
j. Mechanical equipment is not ever likely to be 100 percent effective. However, mechanical cleanup may be "effective" even if all of the oil is not recovered.
k. Dispersants may only be *allowed* in the U.S. with the concurrence of the federal on-scene coordinator. The National Contingency Plan also requires concurrence by EPA, the affected state, and, in some EPA regions, concurrence by NOAA and DOI. The use of dispersants usually should be *acceptable* if dispersing the spilled oil will result in less environmental damage than would be caused by the non-dispersed oil.
   In general, one would prefer to disperse oil into water which is as deep as possible because (1) the resulting concentration of oil and dispersant in water will be lower and therefore less damaging to marine organisms living in the affected area, and (2) the concentrations of oil and dispersant will be reduced reasonably rapidly by diffusion, convection, large-scale eddies, and dilution. However, use of dispersants in shallow water may be the preferred response action if an oil spill threatens to impact an especially vulnerable resource such as a mangrove forest.
   As a guide to thinking about dispersant application rates, a conservative rule would be to allow use of up to one gallon of dispersant per acre per meter of water depth. This rule should be applied with intelligence and understanding. There may be occasions when a higher rate of application would be appropriate in order to protect a highly sensitive resource despite possible damage which the dispersed oil might cause. Use of this rule should avoid any adverse environmental effects from the use of dispersants.[7]
l. Laboratory effectiveness tests should be carried out using preferred candidate dispersants and the oils which are likely to be spilled. Small scale field trials may be appropriate at the time of a spill.
m. Laboratory toxicity tests should be carried out using preferred candidate dispersants and samples of the oils which may be spilled in the area of interest.
n. Sixty acres characterizes the order of magnitude of the area which might be treated within one day by spraying from a work boat.
p. Field determination of dispersant effectiveness usually is based on visual inspection. Dispersant effectiveness depends on the degree of weathering of the oil as well as on the oil itself and on the effectiveness of dispersant application.
q. Surveillance should be continued until spill combat operations are complete.

Method 2. American Petroleum Institute oil spill control decision diagram.[2] This oil spill control decision diagram (Figure 2) outlines the options which are realistically available for oil spill control and suggests strategies that can be used. No guidance is given regarding regulatory acceptance or application rates, but consideration is given to the effects of spill volume, oil products that have been spilled, oil condition (i.e., weathering), weather conditions, and the effectiveness of countermeasures.

If the oil slick is expected to move offshore and is not too close to shore, it may be acceptable to take no action at all, other than to continue to monitor the spill. However, unexpected wind or current changes could cause the oil to strand, or to enter a sensitive shoreline area. Note that both mechanical and chemical response methods are less effective on more weathered oil. Even if oil is spilled miles from shore and calculated spill trajectories show no chance of significant amounts of oil stranding, the presence of a large population of sea birds may require spill control measures.

If an oil slick is moving toward sensitive biological habitats, and the estimated spill volume is less than 1,000 bbl, a choice can be made between mechanical recovery and dispersant spraying—if mechanical equipment is available and winds, waves, currents, and response time are suitable, and if spray equipment is available and the oil is dispersible. This is shown in the lower left part of Figure 2. If neither option is available, the shoreline and sensitive habitats can be cleaned using appropriate methods such as suggested by API[1] or the oil can be left to weather naturally.

Spills of much more than 1,000 bbl have little possibility of being controlled by mechanical means unless conditions are ideal (waves less than one meter and surface currents less than one knot) and a large amount of equipment is available. Dispersant application by large aircraft spraying systems would appear to be the only serious control possibility for large oil spills, as shown in the lower right part of Figure 2. Because it is unlikely that there will be sufficient mechanical equipment available to control larger oil spills, equipment that is available should be used to collect or divert spilled oil as it approaches critical locations.

Mechanical equipment can be more effective than dispersants on spills of oil that are at temperatures below their pour point, are highly viscous, do not spread, or have formed a viscous mousse. If the oil has not spread, mechanical recovery devices have less area to cover.

Chemical dispersants are most effective when applied near the spill source before the oil weathers or incorporates water.

Health hazards must be considered. Mechanical cleanup and spray boat personnel must be protected from volatile hydrocarbons when operating in an oil slick downwind from, for example, an oil well blowout. Special precautions must be taken if the oil and gas contain

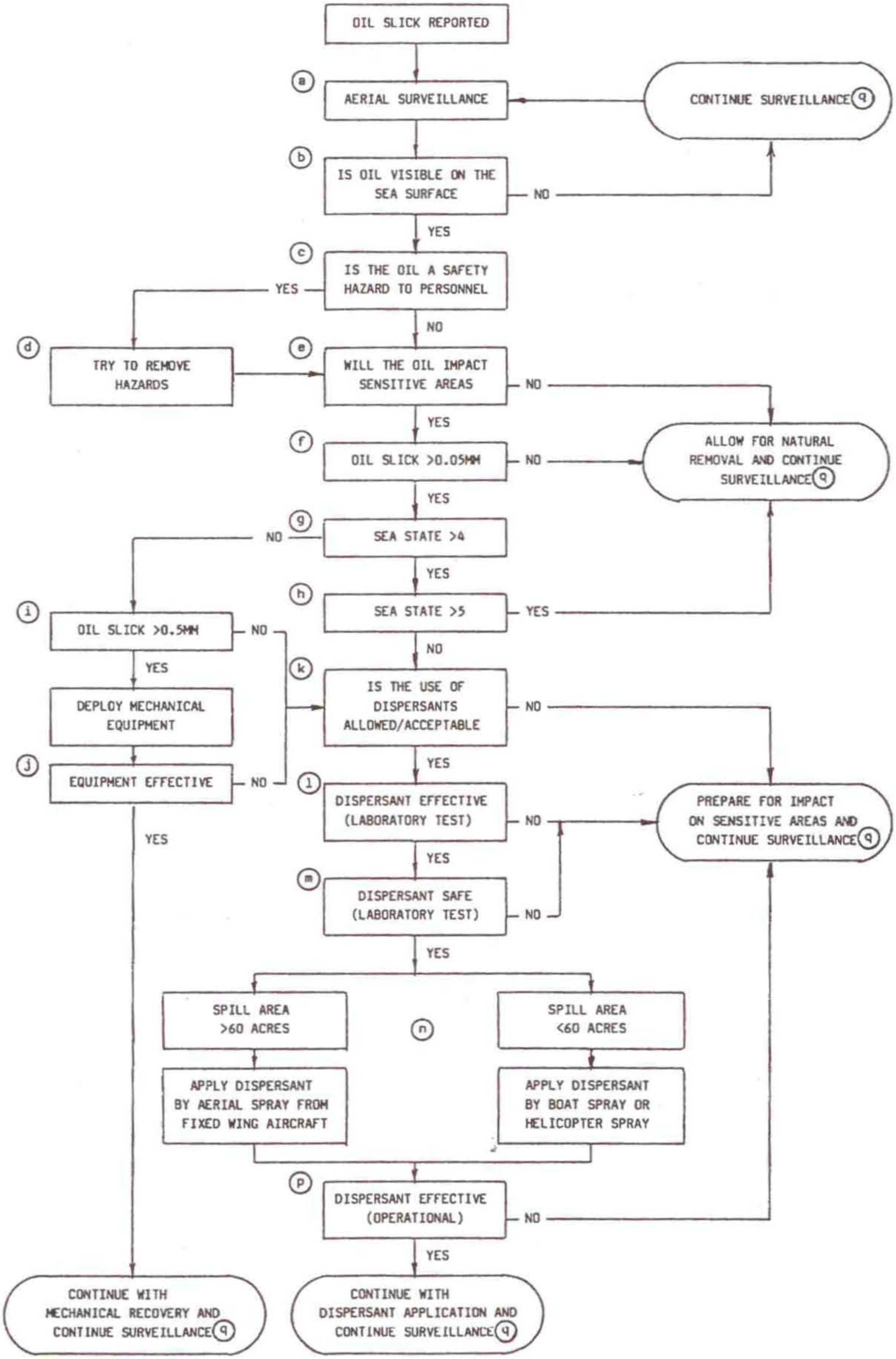
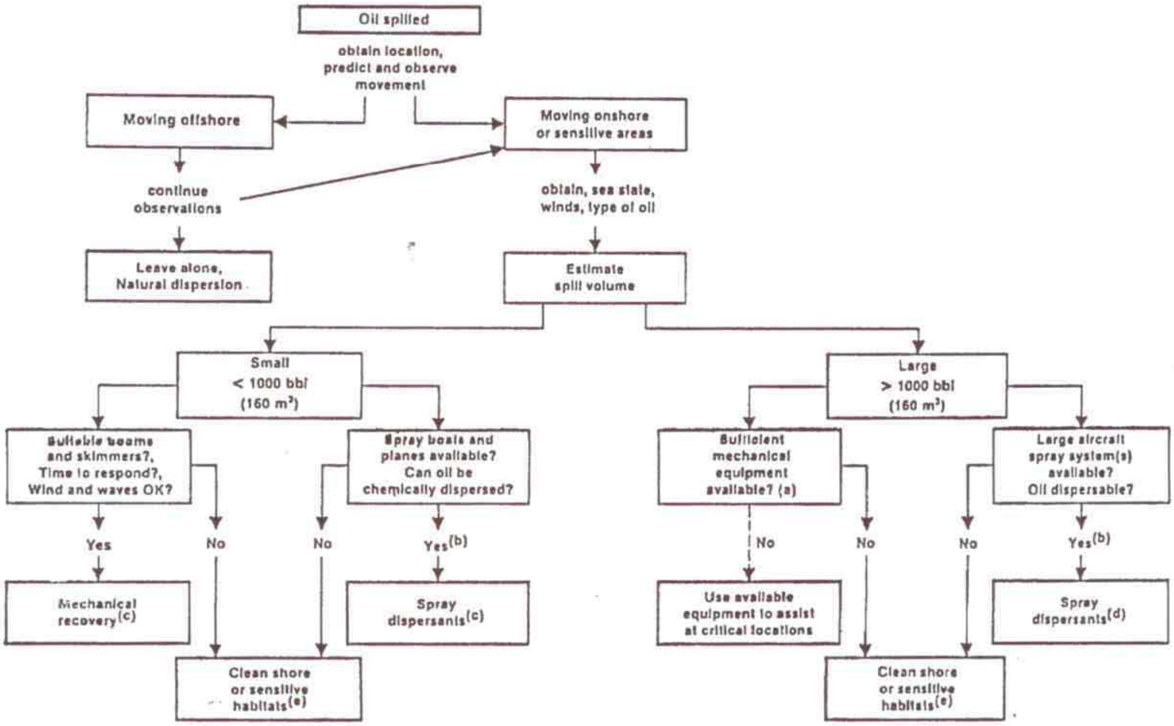


Figure 1. EPA computerized spill response decision tree



(a) It is unlikely that sufficient mechanical equipment will be available to clean up a large spill.
(b) With the approval of the Federal On-Scene Coordinator and the concurrrence of the EPA and the state(s).
(c) Small spills normally should be completely controlled, particularly if both mechanical and chemical methods are used. However, under some conditions some oil may need to be removed from the shore.
(d) Large spills, particulrly 10,000 to 30,000 bbls per day, will be difficult to control. Only large aircraft spray systems are suitable and some oil may still strand. However, oil that is kept off the shore will lessen adverse effects.
(e) Appropriate methods should be used to clean shorelines and sensitive habitats. See, for example, API (1985)

Figure 2. American Petroleum Institute oil spill control decision diagram

hydrogen sulfide. Operations also must be outside the zone where gas and air mixtures are explosive.

Method 3. Canada: guidelines on the use and acceptability of oil spill dispersants.[5] These guidelines are intended to advise when and where dispersants should be considered for use and the minimum requirements for acceptance of a dispersant. General criteria for making dispersant use decisions are included, but no specific guidance is given for evaluating the inescapable environmental tradeoffs.

The decision tree shown is offered as an aid to the on-scene commander and persons advising him (Figure 3). In general, chemical dispersants should be used only with the approval of Environment Canada, subject also to the requirements of the provinces or territories concerned, as appropriate.

Dispersants may be used: (1) when their use will prevent or reduce hazards to human life or safety, or reduce substantial hazards to property; or (2) when their use will minimize the overall environmental impact of an oil spill to aquatic life or habitats, taking into account that tradeoffs may be necessary.

Dispersants generally should not be used: (1) in waters containing major fish or shellfish populations, or in waters that are key breeding or migrating areas for aquatic life which may be damaged or reduced in market value by exposure to dispersants or dispersed oil; (2) in any waters where such use may adversely affect surface water usage (such as for drinking water or industrial use), (3) where eventual dilution of the dispersed oil is limited either because the water exchange is slight or because the total volume of water available is relatively small; (4) on natural shorelines; or (5) under conditions in which the dispersant would be ineffective.

In the decision-making diagram (Figure 3), Step A considerations include viscosity, turbulence, application rate, salinity, and effectiveness. Step B considerations include safety and human health (fire, proximity to drinking or industrial water supply intakes), and environ-

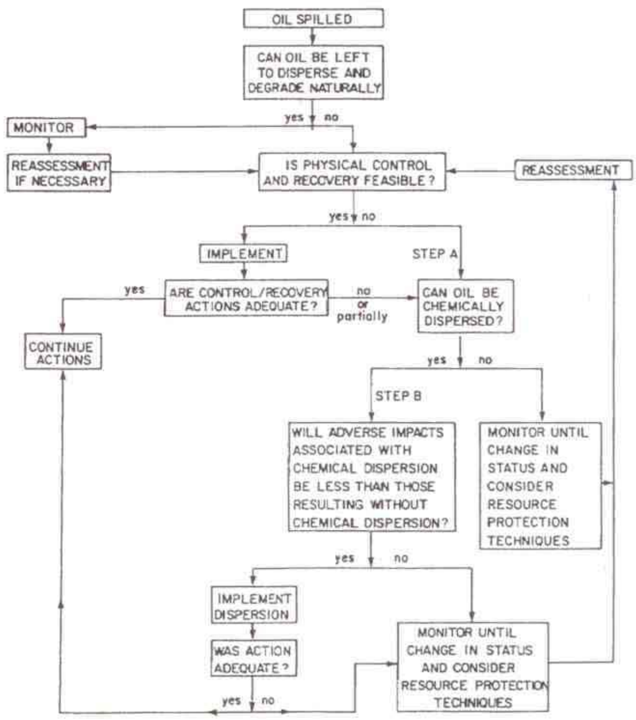


Figure 3. Environment Canada dispersant use decision tree

mental concerns (confined waters, use offshore, and use in nearshore waters).

Method 4. IMO/UNEP guidelines on oil spill dispersant application and environmental considerations.[8,9] These guidelines contain practical information which may be useful to those concerned with the use of dispersants at sea. They constitute a basically textual reference, including information on dispersant principles, types, and effectiveness, application techniques, physical effects of dispersants, environmental considerations, testing, monitoring and assessment, and decision making. An example of one procedure for logically deciding which option to take to mitigate an oil spill (including the possible use of dispersants) is shown diagramatically (Figure 4). As pointed out in the text, this diagram is based on two objectives: to remove the oil where it can effectively be removed, and to minimize adverse impacts.

The guidelines note that, when dealing with larger spills, especially when they are getting close to or occur near the coast, it may be necessary to use all available means in combination, if an effective response is to be achieved.

Method 5. State of Alaska dispersant use guidelines.[13] Dispersant use in Alaska will only be considered as a possible response option when mechanical containment and recovery response actions are not workable. Figure 5 outlines the logic which would be used by the OSC to determine the feasibility of chemically dispersing oil spills in environmentally sensitive areas. The user must assemble a significant amount of information prior to making a dispersant use decision, including a comparison of the effects of dispersed oil and untreated oil on populations at risk. However, no guidance is given the user as to how to make the comparison.

The dispersant use criteria developed for Alaska classify coastal waters into three dispersant use zones. In all cases, the use of dispers-

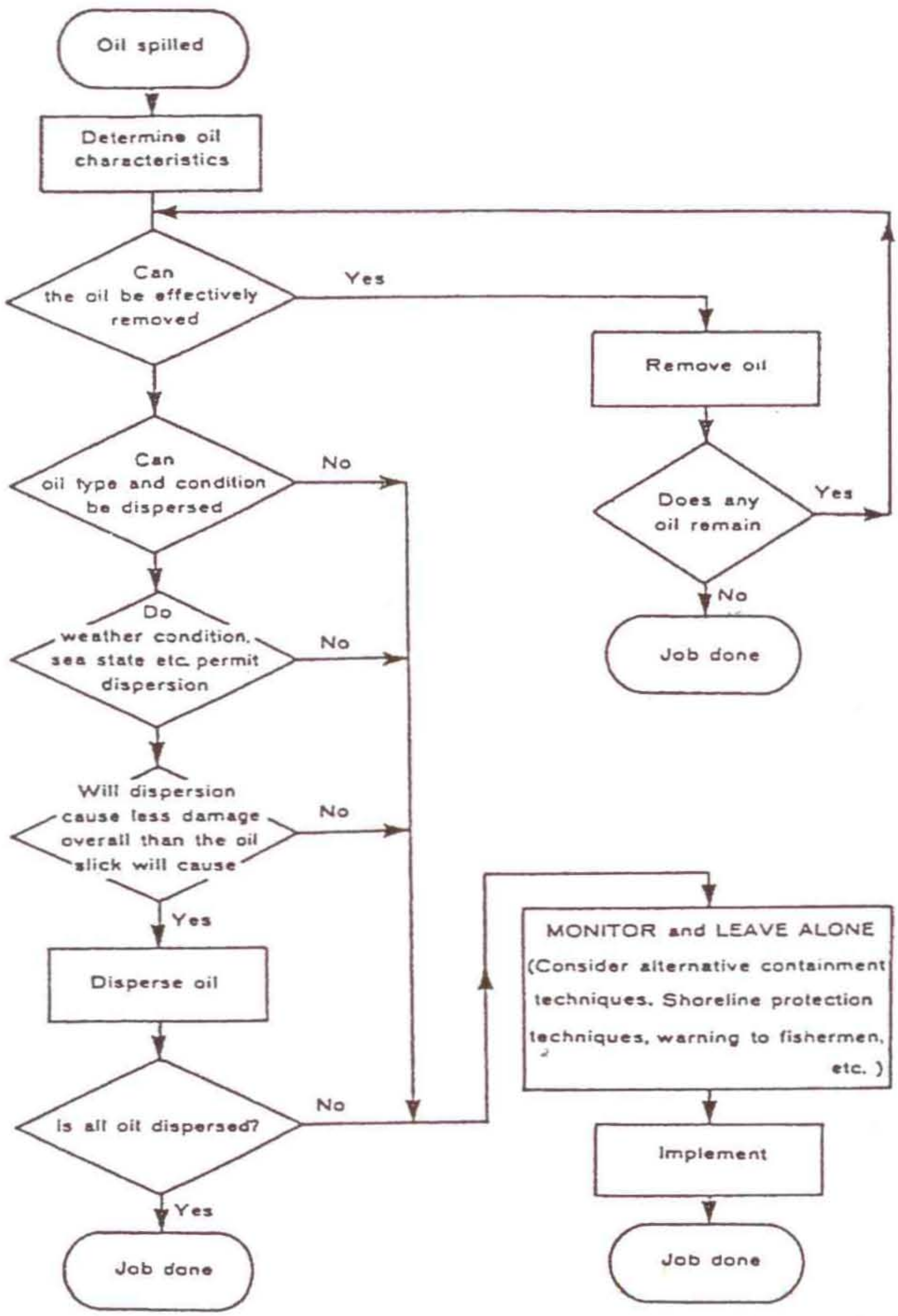


Figure 4. IMO/UNEP—Example of a typical oil spill response decision procedure (with particular reference to oil spill dispersants)

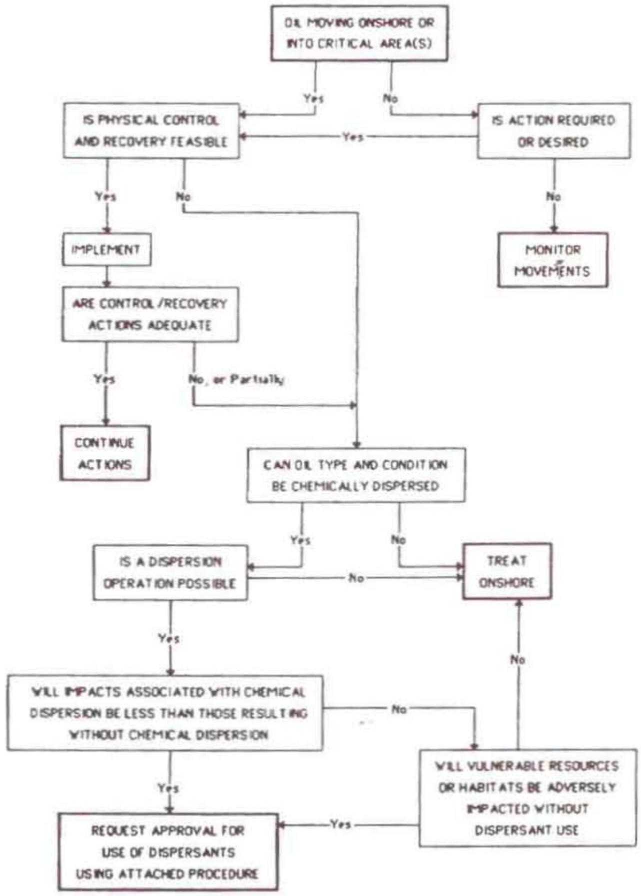


Figure 5. State of Alaska dispersant use decision matrix

ants is based on the determination that the impact of dispersants or dispersed oil will be less harmful than that of non-dispersed oil, although the guidelines do not instruct the user as to how to make this determination. The zones are defined by physical parameters such as bathymetry and currents, biological parameters such as sensitive habitats or fish and wildlife concentration areas, nearshore human use activities, and time required to respond.

Zone 1. The use of dispersants in Zone 1 is acceptable. The OSC is not required to seek approval by EPA or the State of Alaska prior to use of dispersants in this zone but must notify EPA and the state of the decision as soon as possible. Zone 1 areas are characterized by water conditions (depth, distance, and currents) that will allow dispersed oil to be rapidly diluted to low concentrations, and are far enough away from sensitive resources that dispersant operations would not cause disturbances. In this zone, there is a significant likelihood that spilled oil will impact sensitive resources and an immediate response is required in order to mitigate potential environmental consequences.

Zone 2. The use of dispersants in Zone 2 is conditional in order to protect sensitive wildlife and other resources. The OSC is required to consult with the regional response team (RRT) and to obtain approval from EPA and the State of Alaska prior to the use of dispersants in Zone 2. Zone 2 areas are characterized by water conditions (depth, distance, and currents) that will allow rapid dilution of dispersed oil to low concentrations, and by being a sufficient distance from sensitive resources that an immediate response is not necessary and dispersant operations would not cause disturbances.

Zone 3. The use of dispersants is not recommended in Zone 3, although use may be permitted if, on a case-by-case basis, it is determined that the disturbance of the organisms and direct exposure to dispersants or dispersed oil would be less deleterious than the impact of spilled oil. The guidelines do not instruct the user as to how to make this determination. As in Zone 2, the OSC is required to consult with the RRT and to obtain approval from EPA and the State of Alaska prior to the use of dispersants. Zone 3 is defined as the area immediately in or around resources which require protection, including the resources themselves. Dispersant use in this area may disturb resources, may not have adequate time for effectiveness, may directly expose resources to dispersants, or may expose other resources to unacceptably high levels of dispersed oil.

The State of Alaska is mapping areas of its coastline using these zone definitions.

Method 6. Federal Region IX (California) dispersant use guidelines.[4,14] The dispersant use guidelines in California (Federal Region IX) are similar to those in the State of Alaska (above), including the use of the same dispersant use decision diagram (Figure 5). A major difference from the Alaska guidelines is that dispersant use zones have not been defined and maps have not been prepared in California showing areas where the OSC may approve dispersant use unilaterally.

Method 7. Letter of agreement between U.S. Coast Guard and EPA, and the State of Hawaii. Under this agreement, the federal OSC is given limited authority to use dispersants on any dispersible crude or refined oil discharged in amounts between 5 and 500 bbl, under the following conditions.

- No more than 50 bbl of dispersant may be used during each spill, without specific further authorization from EPA and state representatives.
- Application must be during daylight hours and completed with at least three hours of daylight remaining. The three hour limit may be waived, providing the application has been demonstrated to be producing the desired results and continued operation would further minimize pollution.
- All available methods of physical or mechanical removal must have been found to be infeasible, and dispersant use is expected to greatly minimize the adverse environmental impact of the spilled oil. The letter of agreement does not provide guidance on how to evaluate the possibility of minimizing adverse impacts.
- If any marine mammals, endangered species, or significant numbers of migratory fish or birds are known to be present in the spill area, the decision to use dispersants can be made only after consulting with designated members of the RRT.
- Dispersant use is not pre-approved for waters less than 60 feet deep or for any location where the dispersed oil may reach a shoreline, marine sanctuary, national or state wildlife refuge, state marine life conservation district, or estuarine sanctuary boundary within two hours after application.
- Dispersants may not be used in, on, or over shellfish propagation or harvesting waters, waters over reefs, waters designated as aquatic preserves, waters over nursery areas of indigenous aquatic species, waters in coastal marshes, or waters in mangrove forests except with the prior and express authorization of the State of Hawaii and the EPA.

In addition, the OSC is instructed to document each dispersant application fully and to ensure that a comprehensive monitoring plan is carried out. It should be noted that the monitoring plan described in the letter of agreement has not been implemented to date (September 1988).

Method 8. Letter of agreement between the U.S. Coast Guard and EPA, and the State of Florida. This agreement authorizes the OSC to approve the use of dispersants to mitigate the effects of oil spills without further concurrence of EPA or the State of Florida under the following conditions.

- All other methods of physical or mechanical removal have been found to be infeasible, or dispersant use will greatly minimize the adverse environmental impact of the spilled oil. No guidance is given to the OSC as to how to make these judgments.
- Dispersants may be used on open waters that are at least three miles from any shoreline where the water depth is a minimum of twenty meters (65 feet).
- Dispersants also may be used in nearshore waters greater than ten meters (32 feet) depth, where the economic and aesthetic values of a recreational area far outweigh the environmental value, and the use of dispersant has a high probability of preventing the oil discharge from being stranded on the shoreline. If an informed judgment of the relative values cannot be made, express approval of the EPA and the State of Florida is required prior to dispersant use. In any event, in nearshore waters, dispersants are to be used only

when the turbulent mixing and current flow are sufficient to dilute the oil-dispersant mixture rapidly to innocuous levels.

- If necessary, dispersants may be used as an adjunctive means of oil spill control for all major oil discharges (100,000 gallons or more) in marine waters.
- Dispersants are not to be used in, on, or over shellfish propagation or harvesting waters, waters over reefs, waters designated as aquatic preserves, waters over nursery areas of indigenous aquatic species, waters designated as Outstanding Florida Waters, waters in coastal marshes, or waters in mangrove forests except with the prior and express authorization of the State of Florida and the EPA.

The OSC must notify the EPA and the State of Florida immediately if he decides to authorize dispersant use, and must report the dispersant to be used, area affected, application rate and method of application, reason why mechanical or physical removal of the oil is not feasible, the projected area of impact of the oil if it is not dispersed, and the on-scene weather.

Method 9. The SLR dispersant use decision making method.[15, 16] The S. L. Ross Environmental Research, Ltd. (SLR) method for making dispersant use decisions involves comparing rough predictions of the biological impacts of a spill if dispersed or if left untreated (Figure 6). Two criteria are important: the impacts on resources, and the relative value or importance of each of the resources affected. The SLR method is the only method available for determining on a numerical basis (and therefore relatively dispassionately) whether the environmental impacts of chemical dispersion will be less severe than those that would occur without it.

The SLR method, including impact algorithms and a geographical information system (GIS) to keep track of the spatial and temporal distribution of populations at risk, has been programmed for use on appropriate microcomputers. The first application of the computerized system, sponsored by the Marine Industry Group (MIRG), is to potential spills in the U.S. Gulf of Mexico.

The SLR method involves five steps:

1. Compute the location and size of the potentially affected area;
2. Identify resources that might be affected;
3. Estimate the impact of both the treated and untreated spills on each resource;
4. Assess the relative importance of each oil-threatened resource and weigh the predicted impacts; and
5. Compare the predicted impact of the chemically treated spill to that of the spill if left untreated.

Estimates of impact are determined by consideration of the oil fate, the distribution of resources, and the sensitivity of the resources to oil. Owing to the wide range of kinds of interactions between oil and resources, the following resources are considered separately: benthic resources (exposed to oil largely through hydrocarbon contaminated sediments); pelagic resources (exposed to oil via the water); sea birds; marine mammals; shorelines (beaches, mangrove swamps, salt marshes); and property (fishing gear, fish impoundments, marinas). The more important considerations for each group are summarized in Table 1.

The proportion of any resource (such as a stock of shellfish) that suffers a given level of effect (such as tainting or mortality) as a result of the oil spill is determined from an analysis of: the severity of the effects of oil, the proportion of the resource that is affected, and the recovery time (days, months, years).

Relative importance of resources. The value of a resource is subjective and may vary from location to location and may change with economic conditions. In using this decision-making method, the user assigns to the oil-threatened resources a high, moderate, or low importance. Criteria used in this ranking may involve economic, social, or political values, but both the method of ranking and the selection of criteria are left to the user. This ensures that the decisions regarding importance of resources truly reflect local environmental protection priorities.

The decision. Finally, the estimates of impact and the relative importance data are summarized. From an examination of this information the user selects one of the following three decisions.

1. Dispersants *clearly reduce* the overall impact of the spill.
2. Dispersants *clearly increase* the overall impact of the spill.
3. Dispersants neither clearly reduce nor clearly increase the overall impact of the oil spill.

Method 10. Criteria for advance planning for dispersant use (RPI method).[12] Three zones are considered in this method.

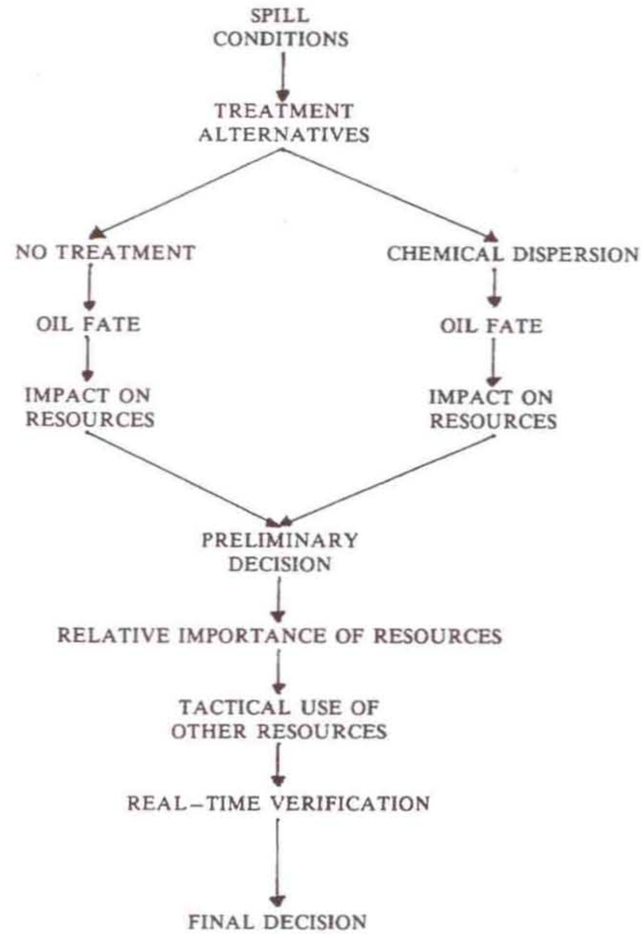


Figure 6. SLR dispersant use decision making method

Zone 1. Dispersant use highly recommended. Based on historical wind and current patterns, oil spilled within this zone is likely to impact sensitive resources. Dispersant use is, therefore, highly recommended for protection of these resources. If applied promptly and effectively, dispersants could produce a significant reduction in the amount of spilled oil stranding on shorelines and reaching sensitive resources. Zone 1 is characterized by sufficient water depth or exchange to allow dispersed oil to be rapidly diluted to low, nontoxic concentrations, and ample distance from sensitive resources so that dispersant application operations will disturb, for example, nesting sea birds or marine mammals.

Zone 2. Dispersant use acceptable. Based on historical wind and current patterns, oil spilled within this area is not likely to impact sensitive resources. Dispersant use is, therefore, acceptable in this zone if spill control is warranted. Zone 2 is characterized by sufficient water depth or exchange to allow dispersed oil to be diluted rapidly to low, nontoxic concentrations, and ample distance from sensitive resources so that dispersant application operations would not disturb them. Spill control action in this zone, other than monitoring, may not be warranted.

Zone 3. Dispersant use conditional. There is significant likelihood that oil spilled in or entering this zone will impact shorelines or sensitive resources. Zone 3 is characterized by shallow water depths and limited water exchange so that benthic organisms may experience exposure to some dispersed oil, and proximity to sensitive resources so that dispersant application operations could disturb them. The preferred action is dispersant use before oil enters Zone 3. However, if oil is in Zone 3, tradeoffs must be considered. A ranking of habitat types according to their relative sensitivities to whole oil and to dispersed oil would be helpful during decision making. If dispersants are used, there will be higher concentrations of chemically dispersed oil in the water column and chemically dispersed oil may impact sensitive

Table 1. SLR method—Summary of important considerations in assessing the impact of oil on resources

Resource	Type response	Conditions
Untreated oil		
Benthic resources	Tainting	• Applies to exploited resources only • Only important in exploited seasons • Only resources at depths less than 10 m affected • Marketability of entire stock may be affected by the possibility of tainting whether tainting has occurred or not
	Mortality	• Effects more important for endangered species than for others • Some or all life stages (eggs, adults, etc.) may be affected • Only resources at depths less than 10 m may be affected • Proportion of population affected determined by ratio of slick area to area of population ("ratio of areas" method)
Pelagic resources	Tainting	• Applies to exploited resources only • Only organisms within 10 m of the surface are affected • Marketability • Effects more important for endangered species than for others • Some or all life stages may be affected • Proportion of population affected is determined by ratio of slick area to area of population
Sea birds	Mortality	• Effects more important for endangered species than for others • Populations are more vulnerable when aggregated for breeding, staging, or migration • Proportion of population affected is determined by "ratio of areas" method
Marine mammals	Mortality	• Effects more important for endangered species than for others • Species that rely on hair for insulation are more sensitive to effects of oil than others • Populations are more vulnerable when aggregated for purposes of breeding, etc. • Proportion of population affected is determined by "ratio of areas" method
Property	Unsightly, inconvenient, unusable	• Recovery times may range from less than seven days to one year or more • If resource is larger in area than the slick, the proportion affected is estimated using the "ratio of areas" method
Shorelines	Mortality	• Effects more severe for highly biologically sensitive shorelines such as salt marshes and mangrove swamps than for others
	Unsightly, unusable	• Oil will be more persistent on sheltered shoreline or on shoreline types that are more permeable to oil than on others • Effects on amenity shorelines may be more severe than on others • The proportion of the shoreline affected is estimated using the "ratio of areas" method
Chemically dispersed oil		
Benthic resources	Tainting	• Applies to exploited resources only • Only important if spill occurs in exploited season • Only resources at depths less than 10 m may be affected • Marketability of entire stock may be affected by the *possibility* of tainting whether tainting has occurred or not
	Mortality	• Effects more important for endangered species than for others • Some or all life stages may be affected • Only resources at depths of less than 10 m may be affected • Proportion of population affected is determined by "ratio of areas" method
Pelagic resources	Tainting	• Applies only to exploited resources • Only important in exploited season • Only resources within 10 m of surface may be affected • Marketability of entire stock may be affected by the possibility of tainting whether tainting has taken place or not
	Mortality	• Effects are more important for endangered species than for others • Some or all life stages may be affected • Populations undertaking breeding migrations may be affected • Only populations in upper 10 m are affected • Proportion of population affected is determined by "ratio of areas" method

Table 2. Summary of ASTM dispersant use guidelines

Habitat	Protection priority	Recommendations regarding dispersant use for Protection	Cleanup
Birds	high	Recommended remote from habitat	Not recommended; no cleanup of any kind recommended near habitat, where it may cause disturbance
Mammals	high	Recommended remote from habitat	Not recommended; no cleanup of any kind recommended near habitat, where it may cause disturbance
Rocky shores	med-high	Recommended remote from habitat	Possible for some situations
Sand beaches	med-low	Recommended remote from habitat	Possible for some situations
Gravel and cobble	low	Acceptable	Possible for some situations
Coral reefs	high	Recommended remote from habitat	Not recommended
Seagrass	high	Recommended remote from habitat	Not recommended
Mangroves	high	Recommended remote from habitat	Possible for some situations
Salt marsh	high	Recommended remote from habitat	Possible for some situations
Tidal flats	high	Recommended remote from habitat	Not recommended
Nearshore	low-high	Recommended remote from sensitive areas	Recommended to minimize impacts
Offshore	low-high	Recommended remote from sensitive areas	Recommended to minimize impacts
Arctic	low-high	Recommended remote from sensitive areas	Possible for some situations

habitats and nearshore areas. The effects of this, both on a long-term and a short-term basis, must be weighed against the effects of whole oil being on the water's surface, impacting sensitive habitats, and stranding on the shore, and an appropriate decision made.

Several logical sequential steps must be taken to apply the dispersant use zone criteria to specific geographic areas in planning for spill control operations. The data to accomplish these steps are available for most areas; however, field work may be necessary for some areas. The steps include the following:

1. Define the geographic area for which dispersant use is to be considered, using NOAA navigational charts.
2. Determine the distribution and seasonality of oil-sensitive wildlife in the area.
3. Identify the socioeconomic resources at risk in the area.
4. Define the coastal geomorphology of the area and the relative sensitivities of the various shoreline types to spilled oil. For this, the NOAA environmental sensitivity index information and similar state data should be used.
5. Obtain applicable meteorological and climatological data.
6. Obtain hydrographic data (such as currents) for the area.
7. Using the data obtained in steps 2, 3, and 4, plot the oil-sensitive wildlife data, socioeconomic resources, and shoreline types on the navigation charts for the area.
8. On the navigation charts, identify those areas where dispersant application operations could disturb sensitive resources such as nesting seabirds or marine mammal aggregations, or could expose benthic organisms to dispersed oil (as in shallow water). Using the dispersant use zone criteria, identify these areas as Zone 3.
9. Using the meteorological and climatological data obtained in step 5, determine the offshore and coastal areas where if oil were spilled it would (a) be likely to impact sensitive resources, and (b) be unlikely to impact sensitive resources. Using the dispersant use zone criteria, identify (a) areas as Zone 1, and (b) areas as Zone 2.

It is possible that seasonal variations in wind and currents could vary the locations of Zones 1 and 2. For these circumstances, separate charts should be used for each seasonal variation. During an oil spill incident, locations of the dispersant use zones may have to be adjusted based on actual wind conditions at the time.

Method 11. ASTM dispersant use guidelines.[3,11] The ASTM guidelines consider dispersant use both to protect habitats and to clean out contaminated habitats. They also identify those habitats that, based on ecological considerations, should be given high priority for protection should a spill occur. Recommendations are different for protection and cleanup. Guidelines were developed for the following 13 areas: bird habitats, marine mammal habitats, rocky shores, sandy beaches, gravel and cobble beaches, coral reefs, seagrass beds, mangrove swamps, tidal flats, nearshore subtidal habitats, offshore habitats, saltmarshes, and arctic habitats.

Each guideline has an introductory section describing the habitat. A background section discusses the effects of oil spills and of dispersant use (if known) in the habitat. This section also identifies those habitats that are most sensitive to the longer lasting effects of oiling and recommends that they be given high priority for protection (using dispersants or other methods) should a spill occur. The next section makes specific recommendations about whether and how to use dispersants to protect the habitat, as well as recommendations on dispersant use during cleanup. For example, the bird habitat guideline recommends dispersant use remote from bird habitats to prevent or reduce the amount of oil entering them. Dispersant use is not recommended in bird habitats as an oil removal method. A summary of the recommendations in the guidelines is shown in Table 2.

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